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Regional Manufacturing Employment Volatility in Canada: The Effects of Specialization and Trade

by John R. Baldwin and W. Mark Brown

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Abstract

This paper measures the volatility of manufacturing employment growth across Canadian regions for the period 1976-97. It also attempts to relate the structural characteristics of regional economies to their levels of employment volatility. In particular, the analysis focuses on testing whether diversity, growth, plant size and export intensity are empirically related to volatility levels.

Using cross-sectional analysis, the paper shows regions that are more stable tend to be more diverse, have lower than average growth rates, larger plant sizes and higher export intensity. These relationships are stronger for regions that have low manufacturing employment than for those where manufacturing employment is larger.

Different results emerge when changes in volatility between the first and the last half of the period (1976-87 and 1988-97) are examined. Although increased diversity and export intensity are associated with decreased volatility in larger regions, these variables have the opposite effect on smaller regions. We therefore conclude that the admonitions about diversity and the benefits of increasing trade liberalization are not felt equally. They may be beneficial in terms of reducing volatility in larger regions, but they have not done so in smaller regions. The very nature of the small regions makes their adjustment to structural change much more difficult.

Finally, the paper shows that increases in export intensity affects the underlying structures of regional economies. Regions with high export intensity and increases in export intensity are more specialized and becoming more specialized, respectively. Higher export intensity and increases in export intensity are also associated with larger and increasing plant sizes, respectively. The movement to freer trade between Canada and other countries then is associated with structural shifts in the Canadian economy that have offsetting effects on volatility. Increased trade is associated with larger plant sizes, which tend to dampen volatility, and decreases in diversity, which tends to magnify volatility. When these offsetting effects are taken into account, the finding that increased trade liberalization tends to reduce volatility for large regions, but increase volatility in smaller manufacturing centres still holds.

Keywords: employment volatility, economic diversity, international trade, regional economic change

Executive Summary

Diverse economies are often said to be desirable because they will be less volatile and more innovative. In this paper, we investigate the validity of the contention that volatility of employment growth and diversity of industrial structure are negatively related across Canadian regions. In addition, we ask how the changing export orientation of Canadian regions has been related to changes in their volatility. Growing exports are theoretically associated with increasingly specialized regional economies, and therefore, economies that may be more volatile.

A longitudinal panel data set is used to study the volatility of the Canadian manufacturing sector for a cross-section of Canadian regions (census divisions), whose boundaries are held constant, for the period 1976 to 1997. Volatility is measured as the variance of a region's annual employment growth rate over the 1976-1997 study period.

A number of questions are examined:

1. *Are rural regions more volatile than urban regions?*

   For this exercise, census divisions are divided into an urban/rural hierarchy—core areas of the large metro areas, their suburban fringes, medium metro areas, small metro areas, and two rural areas—those adjacent and not adjacent to metropolitan regions.

   Volatility is lowest in the core of the large metro areas and highest in the two rural areas. The latter are at least five times as volatile on average as the core metro areas. The volatility of medium and small metro areas lies in between the core and the rural areas. Suburban metro areas exhibited the most volatility of the four metropolitan areas, potentially because of the substantial shift in employment from the core to the suburbs of large metro areas over the period.

2. *Has the changing industrial composition of regions between 1976 and 1997 resulted in manufacturing economies that are more or less stable?*

   For large metropolitan regions, their suburban fringes, and medium sized metropolitan areas, change in their industrial makeup had a relatively small absolute effect on their levels of employment volatility. However, in smaller metropolitan areas and rural regions, shifts in their industrial structure were associated with increased instability. For smaller metropolitan regions, this was because of the increased importance of industries whose growth rates were more synchronized, which tends to dampen the potential benefits of diversification. On the other hand, in rural regions it was the concentration of employment in more volatile industries that was most likely the cause of greater volatility.

3. *How is the volatility of a region related to certain average structural characteristics?*

   The paper investigates whether volatility is related to export intensity and to other underlying characteristics, like industry diversity, plant size, growth rates, and total manufacturing employment.

   In the cross-sectional analysis reported herein, regions that are more diverse, have lower than average growth rates, larger plant size and higher export intensity are found to be more stable. Conversely, regions that are more specialized, that have smaller plants and that have lower exports are more volatile.

   This study also investigates whether the relationship between volatility and industrial characteristics differ between larger regions (more than 1000 employees in the manufacturing sector) and smaller regions (less than 1000 employees in the manufacturing sector). This relationship is stronger for regions that have low manufacturing employment than for those where manufacturing employment is larger.

4. *How have the structural characteristics (export intensity, industrial diversity, average plant size) of regions changed over time?*

   Export intensity and industrial diversification have generally increased over all regions. The export intensity of both the core and the fringe of the largest metro areas have increased most over the period. Industrial diversity has also increased in most regions but more so in those regions further down the rural/urban hierarchy. Plant size, as measured by average employment, has fallen generally; but this decline has been larger in the medium and small metro areas.

5. *How are changes in volatility related to changes in these structural characteristics (export intensity, industrial diversity, average plant size) of different regions between the first half of the period (1976-86) and the latter half of this period (1987-97)?*

   Changes in diversity and the benefits of increasing trade liberalization have not been felt equally in smaller and larger regions. Increases in diversity, and increases in plant size or export intensity were associated with decreased volatility in the larger, more urban regions. They have had the opposite effect in the less populated, smaller, more rural regions.

6. *How have average plant size and industrial diversity responded to increased trade intensity at the regional level?*

   Areas with high export intensity and increases in export intensity are more specialized and becoming more specialized, respectively.

   Export intensity and changes in export intensity are also associated with higher and increasing plant size, respectively.

The movement to freer trade then has had offsetting effects. It is directly associated with declining volatility in larger regions and it is indirectly associated with increases in plant size and decreases in diversity, which have had offsetting effects on volatility.

When the offsetting effects of growing trade on plant size and diversity are taken into account, we find that increased trade liberalization on balance reduced volatility for large regions, but on balance it increased volatility in smaller manufacturing centres.

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1. Introduction

Diverse regional economies are often said to be desirable because they will be less volatile. Although diversity is a potentially desirable property of regional economies, it may be increasingly difficult to achieve as regions integrate into continental and world markets. That is, through the pursuit of their comparative advantage, regions may be becoming more specialized, and therefore, vulnerable to economic shocks.

In this paper, we investigate the validity of the contention that greater diversity leads to lower volatility for the manufacturing sector in Canadian regions. We also investigate whether Canada's growing export orientation leads to more volatile regional economies. Volatility is measured throughout the paper as the variance of each region's annual manufacturing employment growth rate over the study period (1976-1997).

Reducing volatility has long been a goal of regional economic development agencies (Schoening and Sweeney 1992). Volatility is viewed as an undesirable characteristic for two reasons. First, high rates of volatility are often associated with higher rates of unemployment, because negative economic growth leads to displaced workers who find it difficult to obtain new jobs. Second, high rates of volatility make it difficult for governments to plan long-term investments in public infrastructure such as roads, schools, and hospitals.

In order to reduce volatility, local development authorities often attempt to attract industries that will diversify their region's economic base. Diversification is meant to smooth the 'ups and downs' of the local economy. In Canada, diversification has frequently been the explicit or implicit objective of regional development agencies. For example, one of the main goals of the Western Diversification Fund is to diversify the economies of the western provinces away from their natural resource based industrial structure (Savoie 1992).

Efforts to reduce volatility on the part of regional development agencies may be helped or hindered by other government policies. Trade policy may be one of the most important. Canada's growing trade with the world is the result of trade policy developed at the national level, from the Kennedy and Tokyo round of tariff cuts in the 1960s and 1970s to the Canada-U.S. Free Trade Agreement (FTA) and the North American Free Trade Agreement (NAFTA) in the 1990s. As regions engage in more external trade, they may become increasingly specialized as they focus their production in industries where they possess a comparative advantage (Howes and Markusen 1993). Increasing trade might result in more specialized regional economies that are, in turn, increasingly vulnerable to economic shocks. Therefore, national trade policies may conflict with efforts to diversity regional economies. However, it is not only policies implemented at the national level that could result in increased volatility. The same may also be true of policies developed by regional governments.

Many regional economic authorities have pursued policies aimed at encouraging economic growth through export promotion, which, again, potentially leads to more specialized regional economies.[1] In a similar vein, regional development agencies have sought to develop clusters of firms in similar or related industries. Many researchers point to the benefits of clustering, which include innovation externalities that result from competitors locating close to each other (Porter 1998; see also Glaeser et al 1992); the potential knowledge spillovers amongst firms; and, access to specialized suppliers and pools of skilled workers that are required by industries (Marshall 1920 and Krugman 1991). These economies are intended to enable firms to achieve a competitive advantage and export success, but again may also lead to more specialized regional economies. Therefore, when growth policies either directly or indirectly promote specialization, local economic authorities are placed in the position of trading off seemingly contradictory goals—economic growth as opposed to a stable economic environment.[2]

Given the importance of reducing volatility as a policy goal and the potential trade-off between volatility and growth driven by trade policy, this paper has three objectives. The first is to simply measure the level of volatility in the Canadian manufacturing sector in different regions. Very little work has been undertaken in Canada in this area, and therefore, this paper provides a benchmark measure of employment volatility in the Canadian manufacturing economy. The paper's second objective is to test the relationship between specialization, and other regional characteristics, and volatility. That is, we want to know whether regions that are more specialized are, in fact, more volatile. Previous studies undertaken in the U.S. have found this is not always the case. The third and final objective is to test whether specialization driven by trade and volatility that results from economic specialization driven by trade are empirically related.

To guide the research, we ask four related questions. First, how does the volatility of economic growth vary across Canadian urban and rural regions of varying sizes? Of particular interest are volatility levels of rural regions, because rural economies are often characterized as unstable (Schoening and Sweeney 1989 and Siegel, Alwang and Johnson 1995).

Second, we ask how the changing industrial structure of regional economies is related to changing volatility levels? Here we investigate whether the shifting industrial composition of regional economies has been associated with either increasing or decreasing volatility. We try to distinguish between two alternate scenarios. As regional economies evolve over time, they might be diversifying, possibly resulting in lower volatility; but they also might be shifting towards industries that are inherently unstable, thereby leading to higher volatility.

Third, we ask whether volatility is negatively related to the degree to which regions are diversified. Whether there is an empirical relationship between diversification and volatility does not emerge clearly from previous U.S. studies. On the one hand, Kort (1981), Sherwood-Call (1990) and Malizia and Ke (1993) find a positive relationship between diversity and stability. But Attaran (1986) and Smith (1990) question whether diverse regions are more stable. Wagner

[1] Chaundy (2001) has noted that both the federal government, through the Atlantic Canada Opportunities Agency, and the four Atlantic Provinces have all pursued policies aimed at increasing exports.
[2] Wagner and Deller (1998) argue that this contradiction may be more apparent than real. That is, stability and growth can be pursued if, in the short-run, authorities follow a growth strategy, but in the long run, they seek to diversify the region's economy.

and Deller (1998), who go to great lengths to develop and test a more sophisticated measure of diversity, find only a weak positive statistical relationship between diversity and stability.

Wagner and Deller (1998), drawing on the work of several authors, identify four reasons why previous studies have provided inconsistent findings. Specifically, they refer to use of (1) small samples, (2) overly aggregate data, (3) poor measures of diversity and volatility, and (4) a reliance on simple statistical tests as possible reasons for inconclusive results. Our analysis addresses these criticisms by using: a larger sample of regions, highly disaggregate data, and simple, yet logically justifiable, measures of diversity and stability. Furthermore, the analysis utilizes a multivariate statistical framework, which reduces the possibility of missing variable bias.

Finally, we ask whether increasing trade intensity has been associated with increasingly specialized regional economies, as would be suggested by the comparative advantage branch of trade theory and, therefore, whether Canada's growing trading relationship with the world has led to higher levels of economic instability.

Increased trade can lead to specialization across industries or within industries. Falling trade barriers may cause economies to specialize in those industries where they possess a comparative advantage; possibly driven by differences in their relative factor endowments (Ohlin 1933) or because of technological differences that apply across industries (Krugman 1994). External economies, be they country- or region-specific, may also lead to specialization at the industry level (Krugman 1994). Under these theories, trade liberalization will lead regional economies to become increasingly specialized in specific industries (Howes and Markusen 1993).

Despite the attention that comparative advantage is often given in the trade literature, it is important to point out that trade theory does not have a single hypothesis regarding the relationship between trade and specialization. An alternate branch of trade theory suggests the results of increased trade will not so much be an increase in specialization across industries as an increase in specialization within industries. Within industry (intra-industry) specialization occurs when firms specialize in a smaller number of products associated with that industry. This may result from the replacement of many small plants with fewer larger plants and/or fewer varieties of products being produced within each plant. Increasing returns to scale (Grubel and Lloyd 1975, Krugman 1981 and Helpman and Krugman 1985) and technological differences[3] across firms (Davis 1995) have been identified as potential causes of increased intra-industry trade and specialization. Intra-industry specialization by definition does not lead to greater specialization (or less diversity) at the industry level.

Increased trade, in these examples, may impact on plant size, which in turn may have an affect on volatility. Employment in larger plants is, on average, less volatile than employment in smaller plants (Baldwin and Dhaliwahl, 2000). One explanation for this empirical regularity is that the much larger embedded organizational capital associated with large plants dampens their rate of growth and decline. Thus, increasing exports may result in reduced volatility through its affect on plant size. Intra-industry specialization then could have the opposite affect on volatility

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[3] These are defined as Ricardian, Hicks neutral technological differences.

as inter-industry specialization. And, of course, both phenomena may occur simultaneously, thus leading to offsetting effects of changing export intensity.

Therefore, when viewed as a whole, trade theory suggests that the impact of increasing trade on specialization depends on the underlying structural changes taking place—whether resource reallocation occurs across or within industries. In turn, the impact of structural change on volatility depends crucially on the type of structural change that is occurring.

Empirical studies reveal that an increasing proportion of Canada-U.S. trade since the implementation of the FTA/NAFTA is of the intra-industry type (Gu and Sawchuk 2000). This implies specialization is occurring within industries. Furthermore, there is also evidence that, with the implementation of the FTA, Canadian plants have become larger relative to those of the United States, though results do not suggest that scale changes are particularly concentrated in industries where tariffs have gone down the most (Head and Ries 1999). In addition, a smaller number of varieties of products are being produced per plant (Baldwin, Beckstead and Caves 2001), which has allowed the manufacturing sector to take advantage of economies associated with longer production runs. Therefore, there is some reason to believe that, at least in Canada's case, trade has lead to increased specialization at the plant level.

The remainder of the paper is organized as follows. In Section 2, we define the Canadian rural/urban hierarchy and illustrate how the structure of regional economies varies across the hierarchy and over time. Section 3 includes a discussion of how we measure volatility, and the results of our analysis of the levels and components of volatility across the Canadian rural/urban hierarchy. Section 4 tests the relationship between economic structure and volatility using various regression models. Section 5 includes a brief conclusion.

2. Defining and Characterizing the Rural/urban Hierarchy

The research questions outlined above are addressed using a broad cross-section of Canadian regions assigned to a Canadian rural/urban hierarchy classification. In this section, we define the rural/urban hierarchy and characterize it in terms of various structural characteristics of regional economies. Throughout the analysis, we will use data derived from the Annual Survey of Manufactures (ASM) as a basis for measuring the volatility of employment growth and its various correlates used in the regression analysis. We focus on the manufacturing sector because the majority of Canada's exports are in goods produced by this sector (Statistics Canada 2001). Therefore, structural change resulting from increased trade is likely to affect manufacturing the most. The time period for the analysis is 1976 to 1997, the longest period for which we have consistent manufacturing data by census divisions. We examine volatility over the entire time period and between the first and second half of the period (1976-1986 versus 1987-1997).

2.1 Defining the Rural/urban Hierarchy

In this paper, we ask whether volatility differs across rural and urban parts of Canada, whether structural shifts in the Canadian economy have occurred, and whether diversity and other potential correlates are related to differences in volatility across regions and over time.

In order to address these questions, a constant geography of regions over the study period is created. We require a constant geography because we want to ascertain whether changes in volatility arise from underlying structural changes in the regional economies rather than from changes due to the shifting borders that result in some plants being reclassified from one region to an other. For example, if a large plant shifts between regions because of a boundary change, the resulting decline in employment for one region and a rise in the other will cause an increase in volatility for both. This increase in volatility is not due to a structural change, but is an artefact of shifting regional boundaries.

The fundamental geographic unit used in this study is the census division, because it is the most consistent geographic classification below the sub-provincial scale over time. Although the boundaries of most census divisions remain the same during our period of study, in a number of cases, their borders changed considerably. In order to provide a consistent measure of change through time, we held the geography of census divisions constant, with the exception of a few census divisions, to their 1976 configuration. The methodology used to accomplish this is described in Baldwin and Brown (2001).

After the constant regional identifier is created at the census division level, each region is assigned to a location within the rural/urban hierarchy based on 1976 information about the region's size and adjacency to metropolitan areas. Defining a census division's place within the rural/urban hierarchy is also necessary for the analysis because it provides us with a means to compare different Canadian communities based on their population size, which is positively associated with their level of the diversity (Baldwin and Brown 2001). For this purpose, we use a modified version of the Beale rural/urban coding system than was originally developed by the

U.S. Department of Agriculture and that has been modified and applied to the Canadian rural/urban system (Baldwin and Brown 2001).

The six rural/urban categories are summarized in Table 1. The Beale coding system classifies census divisions based upon their relationship to the Canadian rural/urban hierarchy as defined by the size of Census Metropolitan Areas (CMAs) and Census Agglomerations (CAs) that they encompass or in which they are included. The census divisions are classified first by whether they belong to a metropolitan area and then by the population of that metropolitan area. Outside the metropolitan areas, they are classified on the basis of their location relative to metropolitan regions (i.e., Nonmetro-Adjacent versus Nonmetro-Nonadjacent) (see Table 1). Therefore, the Beale coding system contains both hierarchical (size) and geographic (location) components. As such, it provides us with a perspective on the influence of location and position within the rural/urban hierarchy on industrial change.

Table 1. Description of Beale Coding System

Code	Name	Description
0	Large Metro	Central and most populous census division of a CMA with a population greater than 1 million
1	Large Metro Fringe	Remaining census division(s) within or partially within a CMA with a population greater than 1 million
2	Medium Metro	Census division(s) containing, within, or partially within a CMA with a population between 250,000 and 999,999
3	Small Metro	Census division(s) containing, within or partially within a CMA/CA with a population between 50,000 and 249,999
4	Nonmetro-Adjacent	Census divisions that share a boundary with a CMA/CA and the CMA/CA has to have a population greater than 50,000
5	Nonmetro-Nonadjacent	Census divisions that *do not* share a boundary with a CMA/CA that has a population greater than 50,000

Source: Baldwin and Brown (2001).

Note: Because CMA and CA boundaries are different than census division boundaries, census divisions may: (1) contain entire CMA/CAs; (2) be found completely within CMA/CA boundaries; or (3) be only partially within the territory of a CMA or CA. In all cases, the census division is classified using the Beale code that is associated with the size of that CMA/CA.

For this analysis, we maintain a constant Beale classification over the study period. That is, each census division is given a Beale classification based on the 1976 population of CAs and CMAs. This allows us to consistently compare the volatility of Beale-classified regions over time. If the rural/urban classification of regions were allowed to change over time, it would be unclear whether changes in volatility were due the reclassification of census divisions as the population of their related CA or CMA changed over time, or whether it was due to structural changes within the rural/urban category.

2.2 Structural Change Across the Rural-urban Hierarchy

The structures of regional economies vary by diversity, size and export intensity. As a prelude to our examination of differences in volatility and how changes in volatility relate to structural change, this section first describes how the basic characteristics of Beale-classified rural and urban regions have changed over time. The characteristics that are examined are diversity, average plant size, growth rates and export intensity.

Potentially one of the most important forces driving structural change in the Canadian economy over the twenty-two year study period has been the increasing links between Canadian regions and the broader North American and world economy through increased trade. We measure the importance of exports to regional economies by calculating their export intensity. Export intensity is defined as the proportion of the value of manufactured goods produced by firms in a census division that is exported. These proportions are derived from the Annual Survey of Manufactures, which on a periodic basis asks manufactures what percentage of their own manufactured goods are exported.[4]

The average export intensity of census divisions classified by Beale category is reported for 1979 and 1996 in Figure 1. The export intensity of urban and rural areas increased over the 1979 to 1996 period. Export intensity increased the most in Large Metro areas, which have almost caught up to the other regional categories over the period. The growth in export intensity was also strong in the Large Metro Fringe and Nonmetro-Adjacent areas.

The theory of comparative advantage would predict that the degree of specialization should increase as Canadian regions integrate into the world economy. To measure diversity, we use the Herfindahl index, $HERF_r = \sum_i w_i^2$, where w_i is the share of each industry i in census division r. Industries are defined using the 4-digit 1980 SIC. The value of a Herfindahl index ranges from a maximum of 1, where all employment is concentrated in some industry i to a minimum of $1/n$ where employment is evenly spread across n industries.

The average HERF index for census divisions classified across Beale categories is presented in Figure 2. Reported in the figure are average index values for the beginning and end years of the study, 1976 and 1997. There is a strong relationship between diversity and the rural/urban hierarchy. As we move down the rural/urban hierarchy the level of diversity generally falls. Rural regions have much more specialized economies than urban regions, and in particular, the cores of large metropolitan regions.

[4] Contrary to other data that are used herein, the data on exports only covers long-form plants. These plants make up over 92% of sales in the early 1990s.

Figure 1. Average Census Division Export Intensity by Beale Category, 1979 and 1996

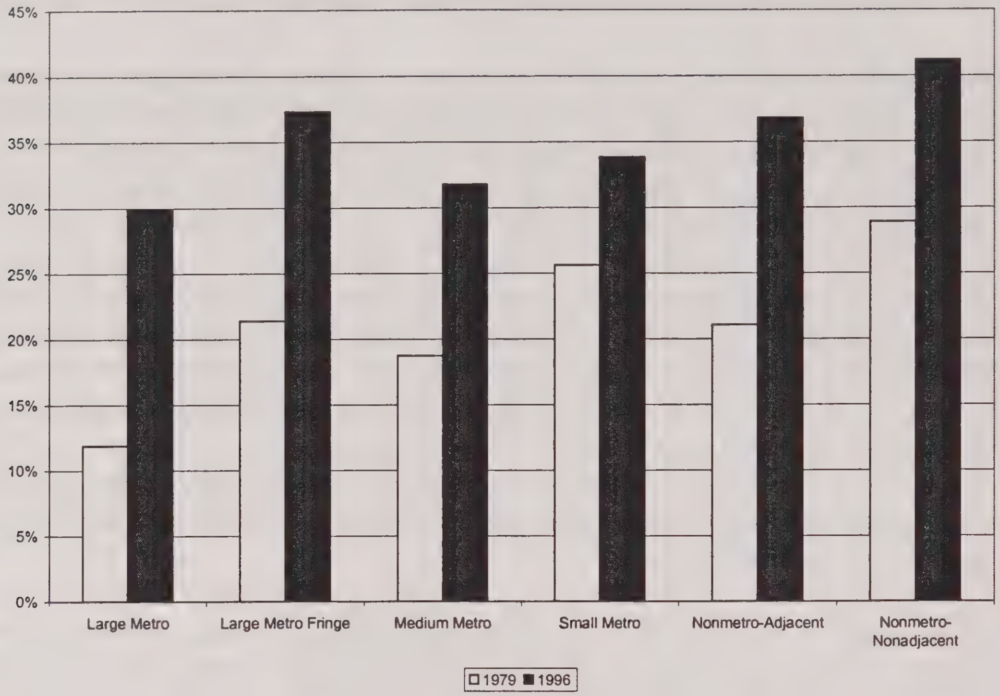
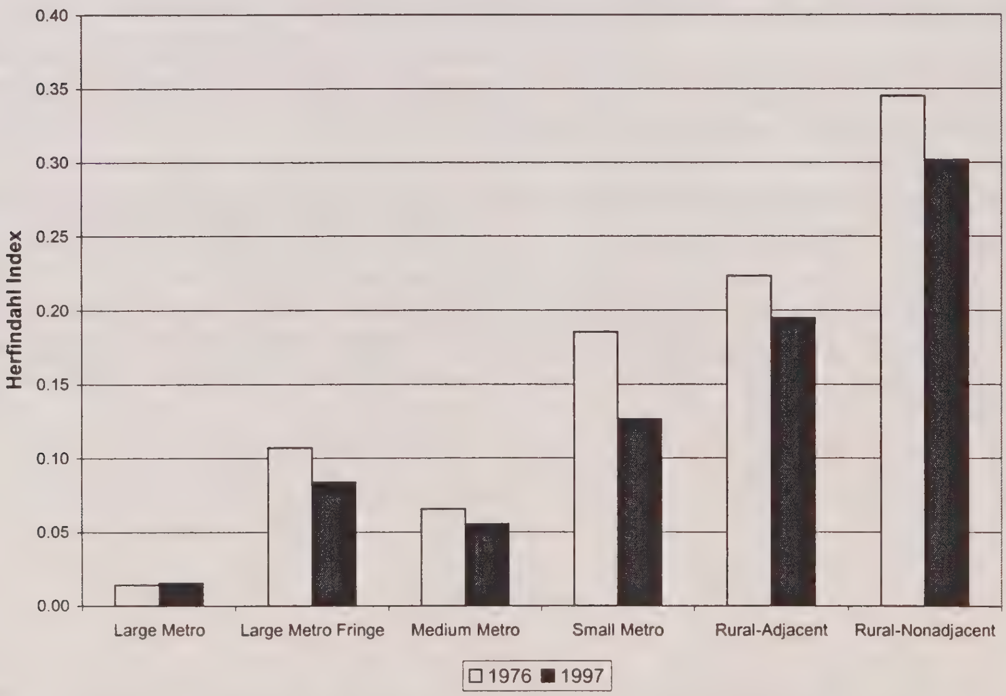


Figure 2. Average Census Division Herfindahl Index by Beale Category, 1976 and 1997



While the differences in the observed levels of specialization accord with our expectations, changes between 1976 and 1997 do not suggest that trade has led to more specialization. There has been a general increase in diversity between 1976 and 1997; with the exception of Large Metro census divisions. This occurred despite the fact that export intensity increased over the period.

There is an expectation that increased trade may have increased plant size as firms increasingly exploited increasing returns to scale. However, the average employment size of plants found in a census division has declined between 1976 and 1997. Figure 3 reports the average plant size—calculated by dividing total employment in a census division by the number of plants—by Beale category for 1979 and 1997.

For the metropolitan census divisions, there has been a substantial decline in average plant size over the period. This phenomenon results from an increasing share of employment in smaller plants and has been reported earlier by Baldwin (1998). The rising share of employment in small plants has been taking place in both Canada and the United States (Baldwin, Jarmin, and Tang, 2002).

Regional economies also differ in terms of their employment levels and growth rates. Average census division employment levels decline rapidly across the rural/urban hierarchy. Although, overall employment levels in manufacturing have remained fairly static, with employment levels only increasing from 1.7 to 1.8 million between 1976 and 1997 (see Baldwin and Brown 2001), there has been change in the employment size of the manufacturing sector in each of these regions over time. Between 1976 and 1997, the average level of manufacturing employment in Large Metro and Small Metro census divisions declined, while average employment in the Large Metro Fringe, Medium Metro and the two rural categories increased (see Figure 4).

Figure 3. Average Census Division Plant Size by Beale Category, 1976 and 1997

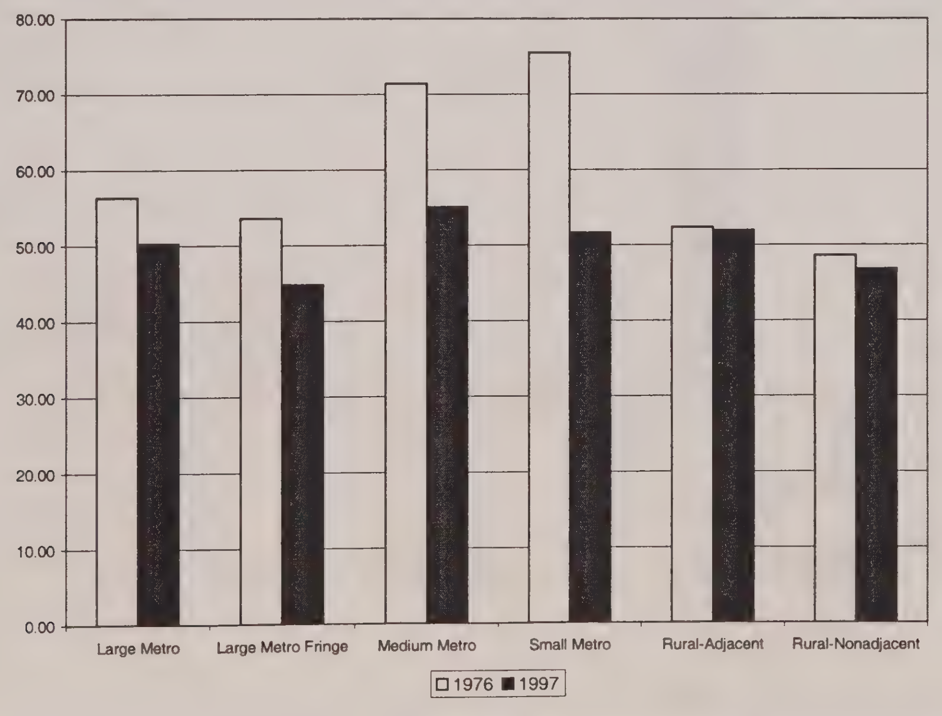


Figure 4. Average Census Division Total Manufacturing Employment Levels by Beale Category, 1976 and 1997

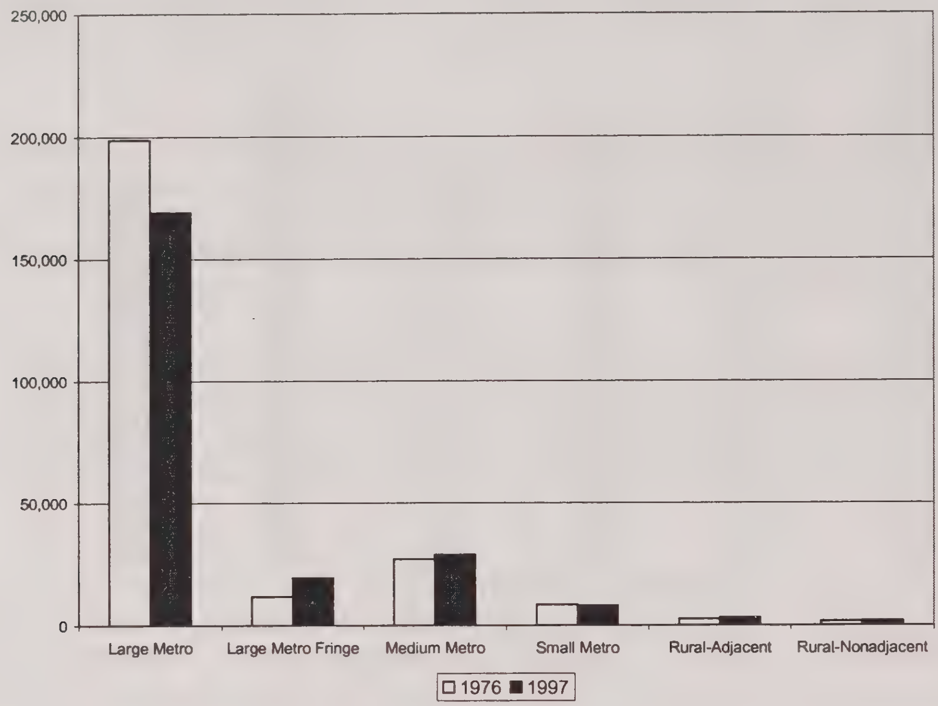
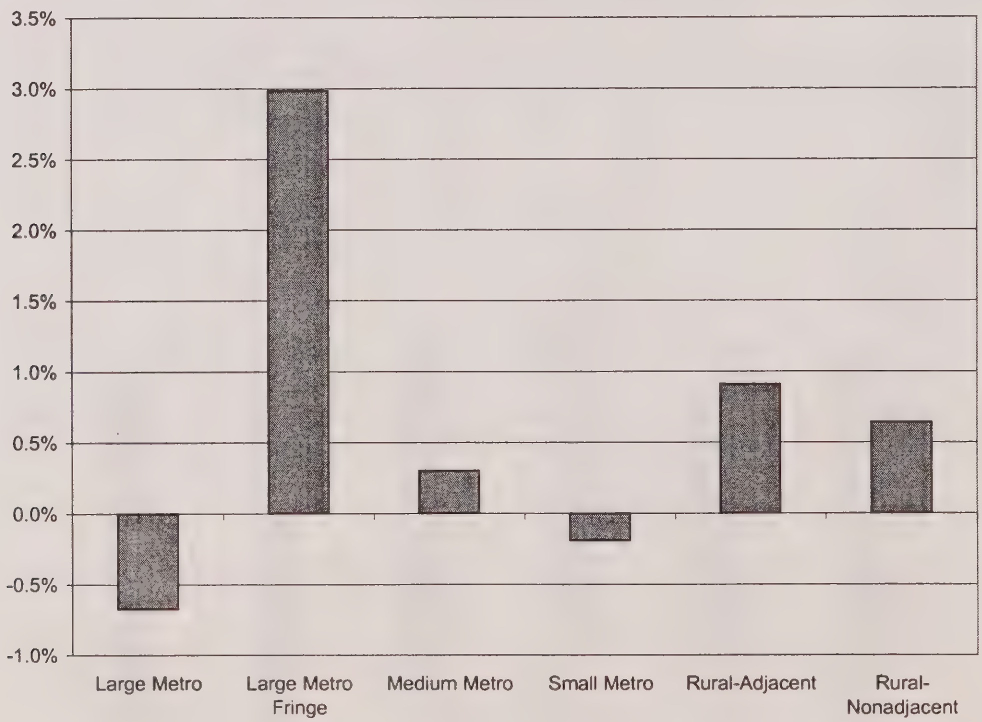


Figure 5. Census Division Average Annual Growth Rates by Beale Category, 1976-1997



The average annual employment-growth rates by Beale category are reported in Figure 5. The highest and lowest (negative) average growth rates were in the Large Metro Fringe and Large Metro regions, respectively. Their relative growth rates reflect the general trend towards the suburbanization of manufacturing employment (Coffey 1994 and Baldwin and Brown 2001). Growth rates were modest in Medium Metro classified census divisions and negative in Large Metro and Small Metro census divisions. The two rural categories had the second and third highest growth rates.

3. Measuring Volatility and Its Components

In this study, we measure volatility as the variance of annual regional growth rates of total manufacturing employment in each census division. We use the variance of growth as a measure of volatility for two reasons. The first is that changes in the rate of growth are often disruptive to a regional economy. This is because of either the labour shortages or unemployment that results from changing rates of growth and also from the difficulty that public agencies face when making long-term plans to build public infrastructure (e.g., road and hospitals) in an environment of economic uncertainty.

The second reason is subtler, but nonetheless just as important. Unlike other measures of volatility (see Schoening and Sweeney 1992), the variance of growth can be decomposed into two components, that which is due to the variance of the growth of individual industries and that which results from the correlations amongst industry growth rates. We do so here in order to inform our statistical models and to examine whether the two components vary in a differential way across the urban/rural hierarchy.

The rest of this section is divided into two parts. The first part discusses the variance decomposition. The second part discusses the levels of volatility across the Canadian rural/urban hierarchy that we have defined above, as well as the relative importance of the components of volatility for these rural and urban classifications.

3.1 Variance Decomposition

In order to measure the influence of changing levels of diversity on volatility, we must consider the nature of both new and incumbent industries in an area. This can be accomplished by decomposing the variance of growth in a region into two components: (i) the variance of growth rates of individual industries (*industry effect*) and (ii) the covariance amongst the growth rates of these industries (*portfolio effect*) (see Sharpe 1970). In particular, the variance of growth, σ_r^2, for region r is given by:

$$\sigma_r^2 = \sum_i w_i^2 \sigma_i^2 + 2 \sum_{i \neq j} \sum_{j \neq i} w_i w_j \rho_{ij} \sigma_i \sigma_j , \qquad (1)$$

where σ_i^2 is the variance of annual growth rates of industry i, w_i is the weight of ith industry, and ρ_{ij} is the correlation between the ith and jth industries found in region r. Growth rates and industry weights are measured by annual employment growth and employment shares, respectively.

Using (1), we can isolate the influence of diversity on volatility by making the strong assumptions that the variances of annual growth rates across all industries are the same and the correlation between industry growth rates is zero. In this case, (1) reduces to

$$\sigma_r^2 = \sigma^2 \sum_i w_i^2, \tag{1.1}$$

where the subscript on σ^2 has been dropped because the variance of growth rates across sectors is assumed to be equal. Interestingly, the summation term, $\sum_i w_i^2$, is equivalent to the Herfindahl measure of economic diversity that we defined above.

In a world consistent with the assumptions that underlie (1.1), volatility will decrease with the number of industries found in a region. Volatility will be equal to $\sigma^2(g)$ if there is only one industry in the region and its minimum value will be $\sigma^2(g)/n$ if all n industries in the region have the same share of employment. Therefore, *ceteris paribus*, volatility should fall as employment shares are spread more equally across industries and/or the number of industries in a region increases. It is this relationship that underlies the argument that diversification of a region's economic base should reduce volatility. Note, however, that this result depends on the assumptions that the covariance of growth is zero and the variance of growth is equal across all sectors.

To illustrate the effect of relaxing the assumption of zero covariance and equal variance of growth across sectors, it is helpful to consider the case where the region in question has two industries, 1 and 2. This allows us to rewrite (1) as

$$\sigma_r^2 = w_1^2 \sigma^2{}_1 + (1 - w_1)^2 \sigma^2{}_2 + 2 w_1 \rho_{12} \sigma_1 \sigma_2 - 2 w_1^2 \rho_{12} \sigma_1 \sigma_2 \tag{1.2}$$

If we assume that $w_1 < w_2$, raising industry 1's share increases diversity. Therefore, taking the first derivative of (1.2) with respect to w_1 allows the isolation of the influence of an increase in diversity on volatility:

$$\frac{\partial \sigma^2(g_r)}{\partial w_1} = 2\left[w_1 \sigma^2(g_1) - (1 - w_1)\sigma^2(g_2) + (1 - 2w_1)\rho_{12}\sigma_1\sigma_2\right] \tag{2}$$

If we assume, as above, that individual industry variances are the same, $\sigma_1 = \sigma_2$, (2) reduces to

$$\frac{\partial \sigma^2(g_r)}{\partial w_1} = 2\sigma^2[\rho_{12} - 1], \tag{2.1}$$

where $\sigma^2 = \sigma_1\sigma_2$. Equation (2.1) implies that increasing diversity will reduce volatility as long as the correlation amongst industry growth rates is below 1, but the effectiveness of diversification will fall as the correlation amongst industry growth rates increases.

To understand the influence of differing industry variances, it is helpful to refer back to (2). The first two terms in the square brackets indicate that an increase in industry 1's share reduces the variance of growth only if the second term outweighs the first. This is more likely the closer w_1 is to zero and/or the larger the ratio of $\sigma^2(g_2)$ to $\sigma^2(g_1)$; that is, the more extreme the initial level of specialization in industry 2 and the more volatile industry 2 is relative to industry 1. Of course, if industry 1 is more volatile than industry 2, the volatility dampening effect of diversification may be completely nullified and in the extreme, diversification may increase volatility. The third term in the square brackets will be positive if the correlation between the sectors' growth rates is positive.[5] In other words, raising industry 1's share of employment also increases the influence of the covariance of 1's growth rate with industry 2's growth rate. Therefore, even if the net influence of the first two terms is negative, the third term may offset their effect. Overall, these results show that there is no analytical solution to the question posed above; there is no unambiguous influence of diversity on volatility.[6] In the following section, we examine the nature of the actual relationship for Canada.

3.2 Volatility Across the Canadian Rural/urban Hierarchy

Several measures of the distribution of volatility across the six Beale rural/urban categories are presented in Table 2.[7] Among these are the mean, the median, and the upper and lower quartiles. The mean of the variance is highest in the two rural categories—Nonmetro-Adjacent and Nonmetro-Nonadjacent—and lowest in the Large Metro category. However, the mean levels of volatility in the rural areas are being driven by a few census divisions with very high levels of volatility. We observe such high maximum variances in those census divisions classified at the lower end of the rural/urban hierarchy because they are the most likely to be populated by a small number of plants, possibly with one dominating overall employment. Consequently, a large layoff in one plant can lead to a 90% drop in employment and rehiring the same workers in the next period can lead to a 900% increase employment.

When median levels of volatility are used, there is still a strong hierarchical relationship between size of region and volatility. That is, the lower down a census division is in the rural/urban hierarchy, the higher the level of employment volatility. The same is true for the lower and upper quartiles of the distributions for each Beale category.

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[5] We ignore the possibility that the covariance between g_1 and g_2 is negative, although this is possible.
[6] MacBean and Nguyen (1980) make a similar point regarding the influence of the commodity concentration on export earning instability.
[7] The sample of census divisions includes only those that had manufacturing employment for every year of the study period.

Table 2. Summary Measures of the Variance of Census Division Employment Growth Across Beale Categories, 1976-1997

Beale Category	Mean	Minimum	Lower Quartile	Median	Upper Quartile	Maximum	n
Large Metro	17.98	10.33	10.33	16.82	26.79	26.79	3
Large Metro Fringe	121.75	33.29	47.32	68.29	124.94	494.34	15
Medium Metro	39.04	9.17	20.90	30.20	40.35	108.84	12
Small Metro	111.98	15.75	34.84	45.51	90.79	859.25	31
Rural-Adjacent	216.09	19.19	57.00	102.62	154.08	3159.57	69
Rural-Nonadjacent	486.40	23.51	65.90	138.03	363.66	12042.64	123

Source: Annual Survey of Manufactures, special tabulation.

The exception to this hierarchical relationship is the Large Metro Fringe. Employment growth has been strongest in these urban fringe census divisions in Canada over the study period. High rates of growth have been associated with higher levels of volatility as in the U.S. (Malisia and Ke, 1993). The Large Metro Fringe classified census divisions may also have higher levels of volatility because they are on average smaller than Medium Metro census divisions (see Figure 4) and, therefore, potentially less diverse.

In Table 3, we decompose the variance of growth into industry own-effects and a portfolio effect.[8] As was the case with the overall measure of volatility of growth presented in Table 2, the level of volatility and the own or industry effect generally increases as we move down the urban hierarchy.

The portfolio effect accounts for 67%, 34%, 19%, 11%, 10% and 2% of the total variance of each level of the urban/rural hierarchy, starting with the Large Metro areas and ending with the Nonmetro-Adjacent rural areas. But this declining trend basically arises because the own-effect increases over the hierarchy. The absolute size of the portfolio effect has no clear trend. It is larger for the adjacent and the non-adjacent rural areas, but also high for areas classified as belonging to the Large Metro Fringe.

In most areas then, coincident cycles are not as large a problem as is the variability of the industries per se—the own-effect. The implication of these results for policy makers in the smaller metro and rural areas is that reducing the covariance of the growth rates of their bundle of industries is of relatively little importance. Rather, it is more important for this group to focus on reducing the industry own-effect, which depends on the volatility of individual industries[9] and the diversity of the region's economy. On the other hand, planners in the Large Metro or Large Metro Fringe areas might pay more attention to how industries fit together—both because the portfolio effect is large in absolute size and large in proportion to total volatility.

[8] The overall effect in Table 3 will not quite equal that described in Table 2 because the decompositions in Table 2 make use of average employment share weights over the period—which change over time in the calculations used in Table 2.

[9] Siegel, Alwang and Johnson (1994) make a related argument. They note that the pursuit of region-wide stability can mask significant industry-specific volatility, which affects both firms and workers associated with these industries.

Table 3. Components of the Variance of Growth Across Beale Categories, 1976-1997 Period

	Components	Average	1976	1997
Large Metro	Own-effect	5.66	5.83	5.50
	Portfolio Effect	11.54	11.51	11.82
	Total Effect	*17.20*	*17.34*	*17.32*
Large Metro Fringe	Own-effect	65.27	65.87	64.64
	Portfolio Effect	33.48	29.76	33.76
	Total Effect	*98.75*	*95.63*	*98.40*
Medium Metro	Own-effect	31.88	30.80	31.85
	Portfolio Effect	7.26	7.22	8.55
	Total Effect	*39.14*	*38.03*	*40.41*
Small Metro	Own-effect	143.18	168.08	164.95
	Portfolio Effect	17.23	7.76	26.49
	Total Effect	*160.42*	*175.84*	*191.45*
Nonmetro-Adjacent	Own-effect	629.28	637.50	961.59
	Portfolio Effect	63.52	84.74	50.58
	Total Effect	*692.80*	*722.23*	*1012.17*
Nonmetro-Nonadjacent	Own-effect	1187.35	1222.78	1681.84
	Portfolio Effect	26.88	18.88	51.30
	Total Effect	*1214.23*	*1241.66*	*1733.14*

Source: Annual Survey of Manufactures, special tabulation.

Since the structure of regional economies can have such a strong influence on volatility through the own-effect, and to a lesser degree, the portfolio effect, it is important to ask what the influence of changing industrial structure (the relative importance of different industries) has on volatility. To examine this, the overall variance is calculated with the individual industry variances and covariances estimated over the entire period and, alternately, using the beginning- and end-year industry employment weights. By using this procedure to calculate the effect of changes in industrial structure on volatility, we make the implicit assumption that the variances and covariances of individual sectors do not change as the industry weights change (Siegel, Alwang and Johnson 1994).[10]

The levels of volatility using 1976 and 1997 employment weights—the beginning and end years of our study period—for census divisions classified by each of the Beale categories are presented in Table 3. Except for Large Metro, average volatility has gone up in all regions over the period. The increases are particularly large for the Small Metro and both rural classifications. For Small Metro areas, the increase in volatility is due to a rise in the portfolio effect, indicating industrial restructuring has tended to be weighted towards industries whose growth rates are more correlated. On the other hand, for the two rural areas it is the own-effect that accounts for most of their overall increase in volatility. Since on average these areas became more diverse over the period (see Figure 2), this is likely the result of in increasing concentration in more volatile industries. Overall, these results show that the changing industrial structure of these regions has resulted in more unstable growth rates.

[10]This may be the case because increasing the weight of a stable sector may reduce the variance of those sectors that supply it. Similarly, the covariances of two upstream sectors may increase if they begin to sell extensively to a common downstream sector.

In summary, the last two sections have shown that there are important structural changes that have occurred over the study period. The manufacturing economies of regions—be they rural or urban—have become increasingly integrated into world markets through exports. At the same time, regions have generally become more diversified and average plant sizes have fallen, on the surface contradicting expectations. The results presented so far also suggest that there is a relationship between diversity and volatility. Rural/urban areas that are the most diverse also tended to be the least volatile. There are, however, other structural characteristics that vary considerably across the rural/urban hierarchy, such as growth rates and employment levels. These may also influence volatility levels. Moreover, the analysis has shown that the industrial structure of regional economies influences volatility. Therefore, in order to understand the independent influence of any one of these variables on the volatility of regional economies, it is necessary to test their effect within a multivariate statistical framework. The next section of the paper presents the results of this multivariate statistical analysis.

4. Correlates of Volatility

The analysis of the variance decomposition outlined above indicates that the variance of regional growth rates depends on: (1) the diversity of a region's industrial structure; (2) the variance of its industries' growth rates; and, (3) the covariance between those growth rates. These can be thought of as structural characteristics of regional economies, which can be used to inform the selection of potential correlates of volatility. This section specifies what these correlates are and estimates their statistical significance and relative importance.

4.1 Choosing the Structural Correlates of Volatility

The correlates of volatility are chosen from structural characteristics—the diversification, size and export intensity of each census division. For the reader's convenience, a table is included that summarizes the variable names, their definition and the expected sign of the correlation between the variable and the measure of volatility (see Table 4).

We use the Herfindahl index (HERF) to measure diversity and hypothesize that it is positively associated with volatility. The Herfindahl index is used rather than other measures of diversity because of the close mathematical association between diversity and portfolio volatility noted above.[11]

The average size of plants found in a region (PLSIZE) is also hypothesized to affect volatility. Small plants are often new and therefore more vulnerable to closure than larger plants (Baldwin, et al., 1999). Therefore, our expectation is that regions populated with larger plants will have lower volatility. There is also an expectation—based on theory and empirical evidence—that with increased trade, Canadian plants will become larger. Therefore, there may be an indirect relationship between trade and volatility through its influence on plant size.

[11] Alternative measures of relative industrial concentration (diversity) were tested and did not perform as well as the Herfindahl index.

Employment levels and growth rates have also been hypothesized to influence volatility levels (see Malizia and Ke 1993). Although there is a strong expectation that total employment in manufacturing and diversity are correlated, and therefore, the effect of a region's size is subsumed in the effect of diversity on volatility, it is possible that total employment may have an independent influence on volatility. Some have argued larger regions may be more stable that smaller ones (Malizia and Ke 1993). The opposite, however, may also be true. Theoretically, regions with higher employment levels should sell a larger proportion of their production in their home market than to external markets (Pred 1966 and Krugman, Fujita and Venebles 1999). In turn, the larger the proportion of production sold to local markets, the more the growth rates in a region's industries will be correlated, as they will be dependent on the same market and thus be subject to the same economic shocks. Therefore, if there are two regions with equal levels of diversity, but one is larger than the other, the larger region may have higher volatility. Total manufacturing employment (EMPLOY) is used here to measure size.

Previous empirical work has found that there is a U-shaped relationship between growth and volatility (Malizia and Ke 1993). That is, those places with negative or very low levels of growth experience high levels of volatility, as do those regions with very high levels of growth. The reason for this finding is unclear. Possibly, those places with low or negative growth or very high growth rates may be reacting to economic shocks. Furthermore, high growth regions may be comprised of new industries that are inherently more volatile than mature industries whose technologies and markets are well developed. Additionally, growth is often driven by the entry of new firms that have higher exit rates than older firms (Baldwin et al, 1999). Growth is measured here as the average annual percentage change in employment (GROWTH) over the study period and its square, GROWTHSQ.

As Figure 1 demonstrates, most Canadian regions have experienced rising export intensities over the period. Although export intensity (EXPORT) is hypothesized to be related to both the HERF and PLSIZE variables and, therefore, to influence volatility through these variables, export intensity may have an independent influence on volatility. As regions export more, they increase the geographic scope of their markets and, as a consequence, they diversify the risk of an economic shock arising from any one regional market. As long as growth rates in the various foreign markets served are not highly correlated with each other and the home market, increasing exports should reduce volatility. On the other hand, if export markets are unstable compared to domestic markets, those regions with higher levels of export intensity may have higher levels of volatility. Therefore, export intensity may have either a negative or positive influence on volatility.

As the variance decomposition illustrates, volatility can also increase if the industrial mix of a region shifts towards more volatile industries and/or industries whose growth rates are more or less correlated. To account for the influence of industrial mix, we include in the model the proportion of production accounted for by natural resource-based (RESOURCE), labour intensive (LABOUR), scale-based (SCALE), product differentiated (PROD_DIFF) and science-based (SCIENCE) industries. Previous work on plant turnover has indicated that the labour intensive and product differentiated industries experienced the largest amount of internal restructuring during the period studied (Baldwin and Rafiquzzaman, 1994).

Table 4. Structural Correlates of Volatility

Variable Name	Variable Description	Hypothesized Sign
HERF	Herfindahl measure of diversity/specialization	+
PLSIZE	Average plant size as measured by employment	-
EMPLOY	Total employment in manufacturing	+/-
GROWTH	Average annual growth rate	-
GROWTHSQ	Square of the average annual growth rate	+
EXPORT	Percentage of manufactured shipments exported abroad	+/-
RESOURCE	Proportion of total employment in natural resource-based industries	+/-
LABOUR	Proportion of total employment in labour-intensive industries	+/-
SCALE	Proportion of total employment in scale-based industries	+/-
PROD_DIFF	Proportion of total employment in product differentiated industries	+/-
SCIENCE	Proportion of total employment in science-based industries	+/-

4.2. Structural Correlates Regression Model Results

In this section, we report the parameter estimates for several cross-sectional models that use the variance of growth as their dependent variable and the hypothesized correlates as independent variables. We include HERF, GROWTH, GROWTHSQ, PLSIZE and EMPLOY, EXPORT as well as the proportion of employment in four of the five aggregate industrial sectors. One sector share (SCALE) is dropped in order to avoid perfect multicollinearity amongst the sector shares.

The estimated regression is:

$$\begin{aligned}&\sigma_r^2 = \alpha_0 + \alpha_1 HERF + \alpha_2 PLSIZE + \alpha_3 EMPLOY + \alpha_4 GROWTH + \\&\alpha_5 GROWTHSQ + \alpha_6 EXPORT + \alpha_7 RESOURCE + \alpha_8 LABOUR + \\&\alpha_9 SCALE + \alpha_{10} PROD\_DIFF + \alpha_{11} SCIENCE.\end{aligned} \qquad (3)$$

For the regression models presented in this, and subsequent sections, we report standardised (beta) coefficients rather than the normal regression coefficients. Standardized coefficients measure the change in the dependent variable (in standard deviations) resulting from a one standard deviation change in the independent variable. As such, they provide us with a means to compare the relative influence of the independent variables.

The results from three cross-sectional regressions are presented in Table 5. The first regression uses volatility levels and average values of the correlates calculated for the whole sample. The second and third cross-sectional regressions are based on volatility levels and average values of the correlates for large and small regions, respectively. Column 2 includes only those census divisions with average employment levels greater than 1000 employees. Column 3 includes census divisions with average employment levels with less than 1000 employees over the study period. We divide the sample into these two groups to determine whether the structural characteristics are related differently to volatility in smaller regions than larger ones. These two groups may differ because smaller centres may be particularly vulnerable to economic shocks, such as the opening of a plant in a new industry. While this may diversify the economy of the

small region and reduce volatility in the long run, its immediate effect will be to increase volatility because of the relative size of the discontinuous change that has occurred. The same sized discontinuity will not arise in larger regions. Therefore, variables like PLSIZE or HERF may affect smaller centres differently.

All of the results presented in Table 5, and in subsequent sections, are estimated using a subset of the full sample of regions. The subset includes only those census divisions whose volatility levels are below the 95th percentile. We restrict the sample because several census divisions have extremely high levels of volatility (see Table 2), which means that these observations can have a strong influence on the regression models' parameter estimates.

The results in column 1 for the sample as a whole explain approximately 64% of the variation in the volatility measure. Most of the maintained hypotheses are confirmed.

Specialization (HERF) has a positive and significant coefficient. Plant size (PLSIZE) has a significantly negative parameter. EXPORT has a negative and significant influence on volatility. Thus, regions with higher levels of industry specialization (less diversification) are more volatile. Regions with a larger average plant size have lower volatility. Regions with a higher export intensity experienced less volatility on average.

Higher growth is associated with significantly higher volatility. Previous empirical work has found a U-shaped relationship between volatility and growth (Malizia and Ke, 1993). We too find a similar U-shaped relationship. GROWTH's parameter is negative and significant and GROWTHSQ is positive and significant. The parameter estimates indicate that the influence of growth on volatility is minimized when average growth rates are approximately 0% per annum, which is below the average growth rate for the restricted sample of 1.6%.

Total employment levels (EMPLOY) in manufacturing have a negative and significant affect on volatility. This confirms Malizia and Ke's suggested sign and implies any increase in the covariance of growth associated with larger regional markets does not result in substantial increases in volatility.

Amongst the four industrial sectors included in the model, higher volatility is found only in regions with a higher than average proportion of employment in product differentiated industries. Regions with industrial structures concentrated in the remaining sectors tended also to have higher levels of volatility than those regions with a large share of production in scale-based industries, but these results were not statistically significant.

Using the standardized coefficients to measure the relative influence of the independent variables, it is apparent that growth (GROWTHSQ) and specialization (HERF) have the strongest influence on volatility levels across census divisions. A one standard deviation increase in each results in an approximately 0.6 standard deviation increase in volatility. The other two most important variables are plant size and export intensity, which have roughly one third of the influence on volatility levels as growth and specialization.

The results for large (column 2) and small regions (column 3) contain both similarities and differences (see Table 5). They are the same both with regards to the effect of diversification (HERF), growth (GROWTHSQ), and size (EMPLOY). They differ in terms of the impact of PLSIZE and EXPORT. Although those larger centres with larger average plant sizes tend to have lower levels of volatility, this relationship is statistically weak. The same is not true of smaller centres. In their case, large plants tend to reduce volatility more than larger centres and the relationship is much stronger statistically. The influence of exports on volatility was also stronger in smaller centres. However, in both cases the statistical significance of export intensity was weaker than in the overall sample. This suggests that part of the significance of export intensity (EXPORT) in the full sample of both large and small regions owes to the difference in export intensity between the two size groups and the difference in volatility of the two size groups.

Table 5. Variance of Growth Using Cross-sectional Regression Models

Variable	All Regions	Large Regions	Small Regions
	Column 1	Column 2	Column 3
HERF	0.5616 (0.0001)	0.5134 (0.0003)	0.5372 (0.0001)
PLSIZE	-0.2266 (0.0004)	-0.1183 (0.0838)	-0.2716 (0.0007)
GROWTH	-0.1665 (0.0519)	-0.1297 (0.2803)	-0.0483 (0.7624)
GROWTHSQ	0.6396 (0.0001)	0.4489 (0.0069)	0.5953 (0.0012)
EMPLOY	-0.0330 (0.1032)	-0.0933 (0.0076)	-0.1545 (0.0723)
EXPORT	-0.2378 (0.0002)	-0.0886 (0.2568)	-0.2199 (0.0621)
RESOURCE	0.0363 (0.5357)	0.2553 (0.0080)	0.0075 (0.9306)
LABOUR	0.0326 (0.4626)	0.0876 (0.2533)	0.0893 (0.1811)
PROD_DIFF	0.0940 (0.0381)	0.0113 (0.8855)	0.1318 (0.0558)
SCIENCE	0.0786 (0.2049)	0.0742 (0.2061)	0.2329 (0.0018)
F	43.12	12.98	10.11
Adj R^2	0.6380	0.4092	0.5836
N	240	174	66

Note: The parameters for each model are reported in their standardized (beta) coefficient form. Standardized coefficients measure the change in the dependent variable (in standard deviations) resulting from a one standard deviation change in the independent variable. P-values are reported in parentheses below each coefficient and are corrected for heteroscedasticity using the White estimator.

Finally, the influence of industry shares varied across the models. Specifically, those larger regions with more resource intensive production tended to have significantly higher levels of volatility than scale based industries found in these regions. For smaller regions, it was the presence of science-based industries that tended to be associated with more volatility.

Overall, the cross-sectional models show that there is a trade-off between growth and volatility, but that this trade-off is most apparent when regions experience average annual growth rates over 0%. The results also show that several different structural characteristics of regional economies are associated with higher levels of volatility; those regions that are more specialized or that have smaller plants tend to have higher levels of volatility. The analysis also indicates that, *ceteris paribus*, export intensity negatively influences volatility. Those regions that are more integrated into world markets through exports are less susceptible to economic shocks. The relationship between diversity or growth and volatility can be found in both small and large regions. In contrast, plant size and export intensity, both influenced smaller centres more than larger regions.

4.3 Correlates of Volatility Change

In the previous section, we investigated the cross-sectional relationship between certain structural characteristics of each region and volatility. The relationship was estimated using values of the dependent and independent variables averaged over the entire period. A cross-section presents a snapshot at a point in time of how differences in characteristics across regions are related to differences in volatility. They do not necessarily provide an accurate picture of dynamics. They do not allow us to infer how changes in characteristics between periods will affect changes in volatility. To examine this issue, we estimate a first difference model that allows for fixed effects.

Volatility levels across the rural-urban hierarchy in the two halves of the time period under study are presented in Table 6. Between the 1976-1986 and 1987-1997 periods, the average census division volatility increased 16% above the average level of volatility in 1976-1986.

Table 6. Mean Variance of Census Division Growth Across Beale Categories, 1976-86 and 1987-97

Beale Category	1976-86	1987-97	n
Large Metro	15.89	19.32	3
Large Metro Fringe	77.71	164.79	15
Medium Metro	35.95	44.45	12
Small Metro	150.60	83.18	31
Nonmetro-Adjacent	232.03	212.91	69
Nonmetro-Nonadjacent	432.55	547.73	123

Source: Annual Survey of Manufactures, special tabulation.

In this section, we investigate how changes in structural characteristics are related to changes in volatility. This allows us to examine whether fixed effects associated with individual census divisions may have biased the estimated parameters in the cross-sections. Fixed effects are unobserved characteristics that vary by region that affect volatility and that are correlated with the structural characteristics. For example, it may be that domestic firms are more volatile. We also know that domestic firms are generally smaller. Therefore, the omission of a variable that captures the importance of domestic firms in a particular region would bias the estimate on average plant size.

In order to correct for fixed effects, we take first differences of the dependent variables and estimate the same equations as above.[12] To accomplish this, we calculate the level of volatility for each census division for two eleven-year periods, 1976-1986 and 1987-1997 and take the difference in the two. We also calculate for each census division the average value for each of the correlates that we used above and the difference in their value between periods. Then changes in volatility are regressed against changes in the structural characteristics.

To illustrate the characteristics of the first difference model we employ, suppose in the first period, t-1, the relationship is:

$$y_{i,t-1} = \alpha + \beta x_{i,t-1} + \gamma_i + \varepsilon_{i,t-1}, \qquad (4)$$

where γ_i is fixed effect for region i that is potentially correlated with $x_{i,t-1}$. This correlation means that estimates of equation (4) that do not contain a measure of the unobservable fixed effect γ_i will lead to biased estimates of the coefficient β.

Now let the relationship in period t be the same as in period t-1 except that the intercept parameter in equation (4) is larger:

$$y_{i,t} = (\alpha + \lambda) + \beta x_{i,t} + \gamma_i + \varepsilon_{i,t}, \qquad (5)$$

where the difference between the intercepts in the two periods is λ. Then if we take first differences, we obtain

$$y_{i,t} - y_{i,t-1} = \lambda + \beta\left(x_{i,t} - x_{i,t-1}\right) + \varepsilon, \qquad (6)$$

where $\varepsilon = \varepsilon_{i,t} - \varepsilon_{i,t-1}$. If (6) were estimated, λ(the intercept) would represent the shift in the intercept term that determines volatility and β should be unbiased because γ_i is no longer present.

[12] Alternate forms that allowed for shifting slope parameters, regression to the mean were also used. But the broad story produced by each of these models was much the same and therefore for expository purposes we report only the simple version outlined in the text.

The regression estimates are presented in Table 7. We have modified the variable names to indicate that they measure change. A prefix D_ in front of the variable name indicates a first difference. In column 1, we include all of the main variables used in the cross-sectional analysis and use the full sample of both large and small census divisions. For the parameters reported in columns 2 and 3, we use subsets based on employment levels that correspond to those used in columns 2 and 3 in Table 5. Column 2 includes census divisions with average employment levels over the study period greater than 1000 and column 3 includes regions with average employment levels below 1000.

Table 7. Variance of Growth First-difference Models

Variables	All Regions	Large Regions	Small Regions
	Column 1	Column 2	Column 3
Intercept[a]	-30.47 (0.3338)	24.95 (0.0463)	-57.31 (0.4473)
D_HERF	-0.1588 (0.2799)	0.3607 (0.0063)	-0.3007 (0.0301)
D_PLSIZE	-0.0310 (0.5342)	-0.2091 (0.0103)	-0.0919 (0.0779)
D_EMPLOY	-0.0160 (0.4105)	0.0095 (0.7681)	-0.3195 (0.0207)
D_GROWTH	0.2874 (0.0147)	0.0720 (0.4141)	0.3692 (0.0109)
D_SQGROW	0.1722 (0.1944)	0.1566 (0.0365)	0.1631 (0.1866)
D_EXPORT	0.1096 (0.2657)	-0.2314 (0.0215)	0.3734 (0.0105)
D_RESOURCE	-0.1204 (0.3744)	-0.0022 (0.9834)	0.0027 (0.9864)
D_LABOUR	-0.0678 (0.4255)	-0.0239 (0.7954)	0.0297 (0.7818)
D_PROD_DIFF	0.0493 (0.6138)	0.0557 (0.5853)	0.2543 (0.0590)
D_SCIENCE	0.1168 (0.5459)	0.3155 (0.1267)	0.1628 (0.4121)
F	3.97	4.09	3.59
Adj R^2	0.1106	0.1517	0.2846
N	240	174	66

[a]The parameter estimates for the intercepts are reported in their natural, rather than standardized, form.

Note: With the exception of the intercept, the parameters for each sample are reported in their standardized (beta) coefficient form. Standardized coefficients measure the change in the dependent variable (in standard deviations) resulting from a one standard deviation change in the independent variable. P-values are reported in parentheses below each coefficient and are corrected for heteroscedasticity using the White estimator.

It is important to divide the sample into small and large regions since the variance of employment growth in small regions is sensitive to the entry or exit of one or two plants. This is less important in larger regions because the opening and closing of plants has less of an effect on overall volatility. The normal churning of the economy at the plant level is less important in large centres than small centres since each individual plant only accounts for a small proportion of employment.

The parameter estimates in column 1 indicate that changes in the degree of specialization have a negative but statistically insignificant influence on volatility. This is contrary to results showing a strong positive association between specialization and volatility in the cross-sectional models. Column 1 also indicates that PLSIZE has little influence on volatility and exports have a positive, although statistically weak influence. Therefore, in contrast to the cross-sectional results, the first-difference model indicates average plant size has little influence on volatility and that export intensity, which had a dampening affect in the cross-section, appears to increase volatility in the first-difference model. We also do not find a U-shaped relationship between growth and volatility in the first-difference model. Generally, the first difference results, when estimated across both large and small census divisions, suggest that the dynamics of change cannot be inferred from the cross-section results. The latter tell us, for example, that volatility is less where diversity is higher—but they do not tell us that increasing diversity in regions will increase volatility in the short run. Indeed, the opposite occurs for all regions taken together.

In contrast, the first-difference results for large regions (Column 2) are similar to the broad findings of the cross-sectional model; that is, increasing diversity, average plant size and export intensity all tend to reduce volatility. Comparing the cross-sectional and first-difference results for large regions directly, it is readily apparent that in both models economic diversity has the strongest influence on volatility. However, unlike the cross-sectional results for large regions, export intensity and plant size have a significant and strong negative influence on volatility change. In fact, the influence of increasing export intensity and plant size is near that of increasing diversity and exceeds growth (D_SQGROW). The latter two are the most important variables in the cross-sectional model. The implication of these results is that changes in diversity, export intensity and plant size have a roughly similar influence on changes in volatility in large regions; no one structural variable is driving volatility change.

For small regions (Column 3) increasing diversity and export intensity tends to increase volatility, while increases in employment levels and plant size reduce volatility for small regions. The standardized coefficients for diversity and export intensity indicate the magnitude of their positive influence on volatility change is roughly the same as their negative influence on volatility change in large regions. The opposite signs for diversity and exports may be because increases in diversity or export intensity are associated with the opening of new plants[13]. The consequent discontinuity leads to a spike in volatility reflected in a large increase in volatility measured between the two periods. All of this points to the extreme sensitivity of small manufacturing regions to economic shocks. It also indicates that generalities about the effect of increasing diversity or export intensity need to take into account the size of the region. At least in

[13] Changes in export intensity may also be associated with the closure of plants. That is, if plants in industries serving domestic markets are closed because of import competition, the export intensity of the region will also increase.

the short run, small regions are less likely to experience the benefit of decreased volatility from increases in diversity or in export intensity. In the long run, these changes may result in industrial structures that are less vulnerable to economic shocks, an outcome to which the cross-sectional analysis points.

4.4 Understanding Structural Change

To this point, the potential correlates of volatility levels have been analyzed using certain structural characteristics of regional economies—diversity, plant size, export intensity and employment size. But diversity and plant size are in part influenced by export intensity and size of region. In this sub-section we develop a simple recursive model that examines how HERF and PLSIZE are related to employment size and export intensity.

Our expectation is that differences in export intensities across regions may have a strong influence on the level of specialisation found in regional economies. In particular, those regions that have higher export levels are likely to be less diverse as they will have specialized in those industries where they have a comparative advantage. In this case, there would be a positive relationship between export intensity (EXPORT) and the HERF index.

Running counter to the effect of export intensity on the HERF index, is the influence of the overall size of regional economies on their diversity. Central place theory (King 1984) and economic base theory (Fujita, Krugman and Venebles 1999) suggest that larger places tend to be more diverse as local markets become large enough to support a wider variety of activities. Therefore, those regions that have a higher level of total manufacturing employment (EMPLOY) will also tend to have lower HERF index values.

The relationship between export intensity and employment levels and the Herfindahl index is presented in Column 1 of Table 8. Consistent with our maintained hypotheses, there are strong, statistically significant relationships between EXPORT and EMPLOY and HERF. Those regions that are more export intensive are more specialized and those that have higher levels of employment are more diverse.

The second column of Table 8 contains the parameters from a regression of average plant size on export intensity and the size of manufacturing employment in the region. If trade were driven by scale economies, the expectation is that plant sizes would be higher for those regions more integrated into export markets. The size of local markets may also have an influence on the size of plants if larger regions facilitate access to a larger pool of labour and/or if large local markets make it possible to produce products using larger plants. Finally, average plant size may also vary with the type of industry found in a region. To account for these possibilities, we include EXPORT, EMPLOY, and sector shares in the model.

Consistent with expectations, there is a positive and statistically significant relationship between export intensity and average plant size (see Table 8). There is also a positive and statistically strong relationship between the total level of employment in a region and plant size. Therefore,

after controlling for industrial structure, it is apparent that those regions that are larger and more integrated into the world economy through trade also tend to have larger plants.[14]

Taken together, the results for the HERF and PLSIZE models reveals that the influence of export intensity on the variance of growth rates operates in two opposite directions. On the one hand, those regions with higher export intensity tend to be more specialized, which in turn increases volatility. On the other hand, greater export intensity is associated with larger plant size, which tends to reduce overall volatility. What remains unanswered is the net effect of export intensity on volatility when its indirect influence is taken into account

To test the strength of the indirect influence of export intensity on volatility, we estimated the cross-sectional model presented in Table 5 with HERF and PLSIZE excluded. This allows us to test whether part of the variance of export intensity correlated with HERF and PLSIZE is also correlated with volatility. The new (reduced-form) model's results were not qualitative different than those presented in Table 5. This was true across the three different samples. The primary difference between the two models was that the negative influence of EXPORT on volatility was reduced. This indicates that although higher levels of exports may reduce volatility, this negative influence is partially nullified by the higher levels of specialization that is also associated with greater export intensity.

Table 8. Structural Variables Regression Models

Variable	HERF	PLSIZE
	Column 1	Column 2
EXPORT	0.4532 (0.0001)	0.4217 (0.0001)
EMPLOY	-0.2050 (0.0051)	0.0789 (0.0215)
RESOURCE		-0.1093 (0.2321)
LABOUR		-0.0487 (0.3700)
PROD_DIFF		-0.1001 (0.0194)
SCIENCE		0.0543 (0.1509)
Adj R^2	0.2495	0.2557
N	240	240

Note: The parameters for each model are reported in their standardized (beta) coefficient form. Standardized coefficients measure the change in the dependent variable (in standard deviations) resulting from a one standard deviation change in the independent variable. P-values are reported in parentheses below each coefficient and are corrected for heteroscedasticity using the White estimator.

[14] Export intensity is measured using responses from the long-form. This implies the relationship between export intensity and plant size may result from the fact that larger plants are the only ones that report exports. However, the positive relationship between export intensity and plant size is robust even after controlling for the proportion of manufacturing sales in a census division is derived from the long-form.

4.5 Correlates of Structural Variable Change

In the last section we reported that exports and total employment levels were correlated with the level of specialization across regions and that exports were correlated with plant size. This section tests whether these relationships continue to exist for changes over time. To do so, we regress the first difference of HERF and PLSIZE against the first difference of EXPORT and EMPLOY. The parameter estimates are reported in Table 9. We follow the same naming conventions as above, where variables with the prefix D_ measure the difference between the average value between the periods 1976-86 and 1987-97. Also included in the models is the first period value of the dependent variables (HERF76 and PLSIZE76), which allows us to test for regression to the mean.

The first column in Table 9 contains estimates of the relationship between changes in export intensity and employment levels and plant size and the change in specialization between 1976-86 and 1987-97. Based on the results of the cross-sectional structural variable models presented in Table 8, we would expect that any change in the HERF index would be positively associated with changes in export intensity and negatively associated with changes in manufacturing employment levels. The expectation for exports is confirmed by the results; there is a positive and highly significant relationship between changes in exports and increases in specialization. In contrast to the cross sectional results, the change in D_EMPLOY has virtually no association with specialization.

Finally, the parameter estimate for the initial level of specialization (HERF76) is negative and highly significant, indicating that there is regression to the mean. That is, those regions that are specialized in the first period will tend to be less so in the second and *visa versa*.

The second column of Table 9 contains the parameter estimates for changes in plant size. The results are consistent with those presented in Table 8. That is, those census divisions with increases in export intensity saw their plant size increasing. Also, those regions that increased their overall manufacturing employment levels between periods also tended to have larger plants.

Overall, the models presented in Table 9 show that changes in the levels of export intensity have been associated with changes in the structures of regional economies over the study period. In short, those regions with increasing export intensity also tended to become more specialized and to have larger plants than regions that are less integrated into world markets. This result is consistent with expectations that increasing trade should result in larger plant sizes. In the context of this paper, these results also imply that an increase in export intensity has an indirect dampening and magnifying effect on volatility through its influence on plant size and regional specialization, respectively.

The net effect of an increase in export intensity on the change in volatility can be estimated by eliminating D_HERF and D_PLSIZE from the first-difference volatility model presented in section 4.3. When the model is estimated with these two variables eliminated, there is no resultant qualitative change in the results. Therefore, after accounting for the indirect effect of increasing export intensity on the structure of regional economies, it remains true that increasing export intensity tends to reduce volatility in large regions and increase it in smaller manufacturing regions.

Table 9. HERF and PLSIZE First-difference Models

Variable	D_HERF	D_PLSIZE
	Column 1	Column 2
Intercept[a]	-0.0024 (0.7861)	-1.0671 (0.8480)
HERF76	-0.3152 (0.0002)	
PLSIZE76		-0.0663 (0.7093)
D_EXPORT	0.1783 (0.0150)	0.2519 (0.0553)
D_EMPLOY	0.0058 (0.6354)	0.0801 (0.0231)
D_RESOURCE		-0.0406 (0.4701)
D_LABOUR		0.0389 (0.5128)
D_PROD_DIFF		-0.0995 (0.0669)
D_SCIENCE		0.0619 (0.1155)
Adj R^2	0.1517	0.0869
N	240	240

[a]The parameter estimates for the intercepts are reported in their natural, rather than standardized, form.

Note: The parameters for each model are reported in their standardized (beta) coefficient form. Standardized coefficients measure the change in the dependent variable (in standard deviations) resulting from a one standard deviation change in the independent variable. P-values are reported in parentheses below each coefficient and are corrected for heteroscedasticity using the White estimator.

5. Conclusion

This paper has examined the relationship between the volatility of manufacturing employment and the diversity of the industrial structure in manufacturing across both urban and rural Canadian regions.

We find that the volatility of manufacturing employment in large urban core areas is considerably lower than in rural areas. The former are far more diversified than the latter. And at first glance, therefore, volatility is related to diversification. This is born out by a cross-sectional multivariate analysis that uses average data for the twenty-year period from 1976-1997 from some 240 census divisions. In these regressions, volatility is positively related to specialization, after controlling for other structural characteristics of census divisions. The same relationship between volatility and specialization is also found using the first-difference analysis. Therefore, unlike many studies, we find a strong and consistent relationship between a regional level of diversification and its stability—more diversified regions tend to be more stable regions.

Specialization is not the only structural factor that is related to volatility. Regions that experience faster growth are more volatile. Regional planners face a trade-off between growth and stability. Adding high growth industries to a region's mix of industries will generally exacerbate volatility. The paper also finds that regions that have larger plants generally have lower volatility.

The impact of increasing export intensity on volatility is felt both directly and indirectly. The direct effect of export intensity tends to be negative—those regions that are more export intensive tend to be less volatile. The indirect effect of export intensity is felt through its influence on the structure of regional economies. Consistent with comparative advantage and increasing returns explanations of trade, regions that are more export intensive or increasing their export intensity also tend to have larger plants and are more specialized: In turn, the cross-sectional and first-difference volatility models suggest larger plants are associated with lower volatility and higher levels of specialization with higher levels of volatility. Canada's growing integration into world markets, therefore, involves forces that both dampen and magnify volatility.

The net of effect of higher export intensity on volatility—after taking into account its direct effect and its indirect effect through plant size and diversity—was found be negative. Those regions that are more integrated into the world economy tend to be less volatile even though they also tend to be more specialized.

It should be noted that we find that those regions that increase their export intensity are becoming more specialized and that the size of plants therein is increasing. Yet on the whole, regions are becoming more diverse and plant size on average is falling. This suggests that there are other structural changes occurring in the economy that run counter to the influences of trade liberalization. Increases in export intensity have had a dampening effect on the broad shifts that have been leading the economy to increases in diversification and smaller plant sizes.

Finally, the paper shows that generalizations about the relationship of changing exports to changes in volatility need to be made with caution because of differences in small and large regions. In large regions, increasing export intensity directly leads to reductions in volatility. But this is not the case for small regions where volatility goes up. For these regions, shifts in their economies towards industrial structures that are less vulnerable to economic shocks in and of themselves result in higher volatility. We, therefore, conclude that the admonitions about diversity and the benefits of increasing trade liberalization are not equally applicable to small and large regions alike. They may be beneficial in terms of reducing volatility in larger regions. They do not do so in smaller regions. The very nature of the small regions makes their adjustment to structural change—even if it is associated with reduced volatility theoretically and empirically—much more difficult.

In conclusion, this paper shows that policies oriented towards diversifying regional economies should help to reduce their vulnerability to economic shocks. The concomitant pursuit of policies to promote exports may work against the objective of promoting diversity, but they do not necessarily result in higher levels of volatility in regional economies; greater export intensity is generally associated with lower levels of volatility. This does not mean, however, that increasing export intensity is without cost. For smaller, often rural, manufacturing economies the economic restructuring that results from increased trade tends to increase volatility, at least in the short-run.

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